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①⑨ ①CA **CANADIAN PATENT** ①⑫

⑤④ DISTRIBUTOR FOR TURBO HYDRAULIC MACHINES

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Granted to Dominion Engineering Works Limited,
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This invention is directed to a turbo machine and in particular to the provision of an integrated scroll case distributor for use with machines of the type including pump-turbines.

In previous arrangements of conventional reaction type turbines and pump turbines the volute shaped scroll casings have been provided with an internal stay ring comprising an annular array of guide vanes for the purpose of maintaining the sectional shape and integrity of the scroll, and to
10 direct the passage of liquid in relation to the slot-like opening of the distributor to which the scroll casing connects. In some instances these guide vanes have been arranged in the stay ring of the scroll case in such a manner as to place certain portions of the vanes under high tension, while other portions of the vanes have been under compression.

In the type of improved design, as shown in Canadian Patent No. 882,490 issued October 5, 1971, Piguet, the points of attachment to the scroll case are made at the centers of the stay vanes, so as to substantially uniformly
20 stress the full cross-section of the vanes in tension. Thus, in existing turbo-machines it has been general practice to provide the scroll casing with a stay ring, to provide constraint by its vane members acting in tension so as to withstand the opening force exerted by hydraulic pressure, which tends to deform the scroll casing so as to enlarge it, tending thus to spread its edges apart.

The adjoining structure, the distributor, to which the scroll casing is attached in the prior art, provides a flow mouth, connecting with the runner of the machine, and
30 having the wicket gates located between the opposed lips of the distributor. Lindquist, CP 726,482 issued Jan. 26, 1966, utilizes the wicket gates to absorb hydraulic deformation



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forces acting on the distributor.

The present invention combines the structure of the distributor as an integral part of the scroll casing, thus providing a scroll casing having a distributor portion integrally combined therewith, having a single series of stay members in the casing, wherein the integrated components of the distributor are adapted to provide a tensile or tying function to the structure of the scroll casing. A sleeve around each of the tying members can transmit compressive forces from the generator if so desired.

In accordance with the present invention the scroll stay ring is dispensed with, the distributor is structurally combined with the scroll casing and the requisite holding tensile force necessary to maintain the form of the scroll and the slot-like passage of the distributor at its predetermined opening is provided by tensile bolts. These bolts may be pretensioned and also may be used as the pivots on which the wicket gates are mounted. Pretensioning is accomplished in one instance by use of a compression sleeve about each bolt, against which the scroll case is compressed by the tensile load of the bolt.

By providing a volute casing have an upper distributor ring and a lower distributor ring each concentric with the polar axis of the machine and secured to the respective edges of the scroll case, the two rings provide by their opposed faces a pair of radially inwardly extending lips defining the mouth of the flow slot. The load-bearing tension members, such as bolts, extending between the two rings, are spaced around the volute, each transferring tensile load from the bolt to the scroll by way of the distributor ring portion of the scroll casing, while permitting the removal of individual ones of the bolts, at shut-down.

In the case of pump turbines, having adjustable wicket gates, the bolts may be located as the pivot for the wicket gates, the gates being suitably modified in cross-sectional profile to accommodate the larger diameter pivot. In such an instance one solution is for the tie-bolts to be connected in compressive relation with the slot lips by way of thrust bearings, somewhat in the fashion adopted by Lindquist, above, in his distributor. This permits pivotal rotation of the bolts while maintaining a tying force against the casing lips, to prevent opening up under the effects of hydraulic pressure acting against the casing.

An alternative arrangement of the tensioned load-bearing tie members utilizes an extended tie bolt having a bridging piece supported on external lug portions of the scroll lips, to transfer the load from the tie bolt to the scroll casing, while permitting use of a substantially unstressed wicket gate, thereby obviating the need of heavy duty thrust bearings to transfer load between the wicket gate and the scroll lips. This also utilizes the tie bolt in non-rotative relations, as a stationary or "dead" axle for the wicket gates.

The present invention may be incorporated into high head or low head machines, resulting in more compact, lighter machine structure, while elimination of the stay vanes can be used to modify the machine efficiency characteristic to a more desirable, less peaky characteristic providing a broader load range of high efficiency performance.

Preliminary calculations give indication that a saving in weight due to adopting the improved arrangement can amount to about 26% of the estimated total turbine weight, while a decrease in scroll outside diameter in the order of 5-6% can typically reduce the ratio of scroll diameter to throat diameter (draft tube width) from a value of 3.44 to a

value of 3.3, approximating to a 4% reduction in ratio.

A further advantage of the present invention is the significantly diminished space requirements which can be of particular value in some projects.

10 The present invention thus provides, for use with a turbo machine such as a turbine and/or pump-turbine, an annular volute-shaped scroll casing providing a liquid flow path of progressively changing section to receive in use a runner in mounted relation in the center of the scroll, with the main axis of the runner extending normally to the plane of the volute, the cross-sectional shapes of the volute normal to the plane thereof having a substantially arcuate wall terminating at an unobstructed mouth slot, extending as an annulus in inward facing relation towards the axis of the volute and generally subtending a minor arc of the respective volute section, and a plurality of rod-like tie members arranged in mutually spaced relation about the periphery of the mouth extending across the mouth in tying relation therewith, the tie members being individually substantially contiguous to the
20 respective pitch circle of the volute section.

The present invention further provides in the above described volute a plurality of wicket gates mounted on respective ones of the tie members for pivotal positioning about the longitudinal axis of the respective member.

It will be understood that the advantages afforded by improved distributors according to the present invention apply both to the radial flow style machine, wherein the mouth slot faces radially inwardly, to provide substantially radial flow, and to the semi-axial flow style machine, wherein the
30 mouth slot is inclined from the plane of the distributor volute to provide semi-axial flow.

Certain embodiments of the invention are described

reference being made to the accompanying drawings, wherein:

Figure 1 is a portion of a diametrical sectional elevation of a turbo machine incorporating a first embodiment of the present invention;

Figure 2 shows a schematic general view of a portion of the length of a second embodiment of the distributor according to the present invention;

Figure 3 is a section at 3-3 of Fig. 2,

Figure 4 is a section at 4-4 of Fig. 2, and

10 Figure 5 is a partial sectional plan view taken at 5-5 of Fig. 1.

Referring first to the embodiment illustrated in Figs. 1 and 5, in Fig. 1 the arrangement shows portions of a first embodiment of the invention having a scroll casing 10 with a median plane X-X, and a runner 30 rotatably mounted within the annulus formed by the scroll, the polar axis of the runner, which constitutes its axis of rotation being represented by the axis Y-Y (displaced).

20 For purposes of contrast with the prior art a super-imposed portion 12 of a scroll casing according to the prior art is shown in phantom, including a guide vane 14 thereof. The significant difference in arrangement of the two casings is apparent, with a marked radial drawing-in of the improved casing relative to the machine axis Y-Y resulting in a significant reduction in the lateral outside diameter of the scroll. Thus in the case of an improved casing, while having substantially the same cross-sectional areas at comparative points around the scroll as a scroll according to the prior art, the pitch circle in the plane X-X of the improved scroll will be
30 substantially smaller. This reduces the mass of the scroll and also its major dimension, to facilitate shipment.

The first embodiment, in Figs. 1 and 5, has a casing

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16 with so-called "live" bolts 18 supported in thrust bearings 40, 42 to supply a tying load between the respective upper distributor lip 20 and the lower lip 22. The lips 20, 22 are integrally welded or bolted and form a part of the structure of the scroll casing. Wicket gates 24 located between lips 20, 22 are secured by keys 26 to the respective bolts 18. A crank 46 secured by key 27 (shown in phantom) in keyed relation with the bolt 18 serves to rotatably position the bolt 18 and its associated wicket gate 24, to a desired position.

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Figure 1 additionally illustrates in part the usual machine elements such as runner 30 having lower band 32, upper shroud 36, blades 34 (one shown) extending therebetween, a portion of the draft tube 38, and a portion of the head cover ⁴¹~~40~~, as is well known in the art.

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The second embodiment, illustrated in Figs. 2, 3 and 4 utilizes a "dead" bolt 48 and a bridging segment 50 carried on lug extension portions 53 from the top lip 52. Nuts 49, 51 carry a selected tension load to the bolt 48, to hold top lip 52 in spaced relation with bottom lip 54. The use is contemplated of a hydraulic piston and cylinder servo-motor combined with each of the nuts 49 or 51 to permit the application of hydraulic loading so as to vary the loading on the bolts 48 and permit control of the leakage at the top and bottom of the respective wicket gate by control of the clearance between the gate 64 and the lips 52, 54.

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A torque sleeve 55 is shown in Fig. 3, having been omitted from Fig. 2 for purposes of clarity. The sleeve 55 connects a crank 56 to the respective wicket gate 64 by means of a flange 60 and two or more pins 65. The provision of one or more plugged bores 67 with which the pins 65 can be selectively aligned permits withdrawal or insertion of the pins 65. This makes possible the removal or replacement of individual

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wicket gates by upward withdrawal of the respective bolt 48 on removal of the lower nut 51, followed by removal of the pins 65, thus permitting the respective gate 64 to be removed laterally from between the lips 52, 54. The gate 64 can then be readily removed through the scroll case.

For purposes of safety the plugged bores 67 are arranged to be in alignment with pins 65 for a position of the gate 64 corresponding to a gate opening in excess of the maximum provided by the wicket gate servo-motor. This prevents
10 accidental displacement of pins 65 during operation of the machine.

Making particular reference to the preferred geometry of the improved casing the pitch circle P, shown chain dotted, is arranged to intersect in substantial coincidence with the axis 70 of the bolts 48. It will be understood that some deviation from this ideal arrangement may be acceptable without departing from the spirit of the present invention.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An annular volute-shaped scroll vessel for use with a turbo-machine, such as a turbine and/or pump-turbine, to provide a flow path of progressively changing section for use with pressurized liquid, to receive a machine runner in mounted relation in the center of the volute, with the runner main axis extending substantially normally to the plane of the volute, the cross-sectional shapes of the volute normal to the plane thereof having a substantially arcuate wall terminating at an unobstructed mouth slot extending as an annulus, in inward facing relation towards the axis of the volute and generally subtending a minor arc of the respective volute section, and a plurality of rod-like tie members arranged in mutually spaced relation about the periphery of the mouth extending across the mouth in tying relation therewith, each tie member being substantially contiguous to the respective pitch circle of the volute section.

2. The scroll vessel according to claim 1 wherein said mouth slot is substantially coplanar with said plane of said volute.

3. The scroll vessel according to claim 1 wherein said mouth slot is inclined from said plane of said volute.

4. The volute as claimed in claim 1 including a plurality of wicket gates located in mutually spaced relation around said slot, being mounted on respective ones of said tie members for pivotal positioning about the longitudinal axis of the respective gate.

5. The volute as claimed in claim 4, said tie members being pivotally mounted, to support said wicket gates for said pivotal positioning.

6. The volute as claimed in claim 4, said tie

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members comprising tie bolt means having said wicket gates pivotally mounted in coaxial supported relation thereon.

7. The volute as claimed in claim 6 wherein said tie bolt means includes selectively variable hydraulic loading means, to permit control of the width of said mouth.

8. The volute as claimed in claim 4, including an upper distributor ring and a lower distributor ring secured to said volute in respective load transfer relation therewith, said tie members comprising bolts connecting said distributor rings, including nut means mountable thereon in load transfer relation to secure said rings in predetermined load transfer relation, having said wicket gates in pivotally mounted relation on said bolts.

9. The volute as claimed in claim 7, including segmented yoke means to permit disassembly of selected individual said tie members and the associated said wicket gate.

10. The volute as claimed in claim 8 in combination with a runner rotatably mounted in coaxial relation therewith.

11. The volute as claimed in claim 1 or claim 2 wherein said tie members are arranged substantially normally to the plane of said volute.

12. The scroll vessel as claimed in claim 1, claim 2 or claim 4 wherein at least some of said tie members are positioned having the polar axis of respective tie members located as a chord of the respective said volute section pitch circle.



